In the Specification

Please replace paragraph [002] with the following rewritten paragraph:

[002] This invention relates generally to satellite positioning system receivers ~~receiver~~ and more practically to altitude aided satellite ~~position~~ positioning system receivers ~~receiver~~.

Please replace paragraph [004] with the following rewritten paragraph:

[004] Satellite positioning systems (SATPS) have been developed that enable SATPS receivers to determine a location upon receiving a SATPS spread spectrum signal from a plurality of satellites. An example of a SATPS is the Global Positioning Satellite (GPS) system maintained by the United States Government. A SATPS receiver must acquire four satellites in order to determine the location (latitude, longitude and altitude) of the SATPS receiver. However, in urban and rural indoor or outdoor environments, fewer than the required satellites may be acquired. Further, strong signal shading and signal fading may adversely affect a SATPS receiver's ~~receiver~~ ability to acquire the satellites. If four satellites are acquired, then a three-dimensional location may be determined. If three satellites are acquired, then a two-dimensional location (latitude and longitude) may be determined if altitude is known. Accurate two-dimensional location with three satellites is further impacted if the altitude is not adequately known, for example, when the SATPS receiver is used in a region of uneven elevation, such as in the mountains. One approach to assisting ~~assist~~ with location determination if three satellites are acquired employs an algorithm that uses the last known altitude calculated from four acquired satellites. However, the more the altitude of the SATPS receiver has changed from the last known altitude, the greater the error that results in the location of the SATPS receiver location determination.

Please replace paragraph [006] with the following rewritten paragraph:

[006] Systems consistent with the present invention provide an approach to determining ~~determine~~ location in a SATPS when only three SATPS satellites are acquired with the use of digital altitude data. The three SATPS measurements are obtained from SATPS satellites and digital altitude data is obtained from a terrain database. Three pseudorange equations and an altitude equation are used to determine the location of the SATPS receiver.

Please replace paragraph [014] with the following rewritten paragraph:

[014] Turning first to FIG. 1, that figure illustrates a satellite position system (SATPS) 100 with a SATPS receiver 102 located on the Earth 104 in communication with four satellites 106, 108, 110, and 112. The SATPS receiver 102 via antenna 114 receives the SATPS spread spectrum signals ~~signal~~ 116, 118, 120, and 122 from the four satellites 106, 108, 110, and 112. The four SATPS spread spectrum signals 116, 118, 120, and 122 are transmitted at the same frequency. It is desirable for the SATPS receiver 102 to be receiving SATPS spread spectrum signals from as many satellites as possible, but to resolve the location, such as the x, y and z or latitude, longitude and altitude coordinates, at least three SATPS satellites in the SATPS system 100 must be in communication with the SATPS receiver 102 along with knowledge of the altitude of the receiver. Otherwise at least four SATPS satellites are required.

Please replace paragraph [016] with the following rewritten paragraph:

[016] In FIG. 2, a block diagram of a SATPS receiver 102 of FIG. 1 in communication with a server 250 having digital terrain elevation data is shown. The SATPS receiver 102 acquires three SATPS spread spectrum signals, such as 116, 118 and 120 at the radio transceiver 202 via

antenna 114. The SATPS spread spectrum signals are filtered by filter 206 under the control of navigation processor 208. The navigation processor 208 is coupled to the filter 206, clock 210, memory 212, and interface 216. The clock 210 may provide a plurality of clock signals from an oscillator to aid in the acquisition and processing of the SATPS spread spectrum signals and additionally provides timing for the navigation processor 208 to transfer data to and from the filter 206, memory 212 and interface 216. The interface 216 may be coupled to a display 214 or the location output data 218 may be outputted by interface 216.

Please replace paragraph [017] with the following rewritten paragraph:

[017] The terrain database is not communicated from the server 250 to the SATPS receiver 102 in the current implementation ~~implantation~~. Rather the code phases are sent from the SATPS receiver 102 to the server 250. These code phases are converted to pseudo-range measurements in the server 250. The computation of position determination using the terrain database is not done in the navigation processor 208. Rather the computation is done in a processor of the server 250, such as controller 256.

Please replace paragraph [018] with the following rewritten paragraph:

[018] If the SATPS receiver 102 is able to only receive or acquire three SATPS spread spectrum signals ~~signal~~, such as 116, 118 and 120, the navigation processor 208 provides code phase information associated with the SATPS satellite signals to the server 250. The server 250 is shown in radio communication with the SATPS receiver 102 via server transceiver 252. The server 250 has a controller 256 connected to the server transceiver 252, clock 258, memory 260, digital terrain elevation data memory 262, and network interface 266. The clock 258 may supply a plurality of timing signals for use by the server transceiver 252, the controller 256, the memory

260, and digital terrain elevation data memory 262. The controller 256 is connected to the memory 260 and digital terrain elevation data memory 262 by a data bus 264. The controller 256 is also coupled to a network interface 266 that enables the server 250 to communicate ~~communication~~ with a larger network. The network may be a PCS network, cellular network, PSTN network, Bluetooth network, or other known wired or wireless type of network.

Please replace paragraph [020] with the following rewritten paragraph:

[020] A request for processing with the use of digital terrain elevation data is received from the SATPS receiver 102 by the server transceiver 252 via antenna 254 and processed by the controller 256 under the control of machine-readable instructions in memory 260. The request from the SATPS receiver 102 contains the code phases that are associated with the appropriate SATPS satellites 106, 108 and 110. The server ~~sever~~ 250 may use the code phases from the SATPS receiver 102 to determine an estimated location. In other implementations, the request from the SATPS receiver 102 may contain an estimate of the location of the SATPS receiver 102. The controller 256 accesses the digital terrain elevation data memory 262 via data bus 264 to retrieve the digital terrain elevation data associated with the SATPS receiver's 102 estimated location. Examples of estimating the location of the SATPS receiver 102 at the server 250 include using either the last known position of the SATPS receiver 102 or a triangulation scheme with directional antennas and known power setting of the radio transceiver 202.

Please replace paragraph [021] with the following rewritten paragraph:

[021] The digital terrain elevation data from the digital terrain elevation data memory 262 is then processed by controller 256 to determine the location of the receiver 102. Upon determination of the location of the SATPS receiver 102, a message containing that location is

sent to the SATPS receiver 102 by the server transceiver 252 via antenna 254. In another implementation, the digital terrain elevation data from the digital terrain elevation data memory 262 is sent to the server transceiver 252 by controller 256 and via antenna 254 and then transmitted to the SATPS receiver 102 and the navigation processor 208 determines the location of the SATPS receiver 102 using the received digital terrain elevation data. In yet other implementations, the digital terrain elevation data may be contained at a common place within the network and the server 250 would access the common place via network interface 266.

Please replace paragraph [022] with the following rewritten paragraph:

[022] Examples of digital terrain elevation data include the 1999 NIMA standard digital dataset (DTED) level 0 for commercial and public use. The ~~THE~~ DTED provides a worldwide coverage and is a uniform matrix of terrain elevation values that provide basic quantitative data of terrain elevation, slope, and/or surface roughness information. The DTED level 0 elevation post spacing is 30 arc seconds (approximately 1 kilometer). In addition to the discrete elevation file, separate binary files may provide the minimum, maximum, and mean elevation values computed in 30 arc second square areas. Another example of digital terrain elevation data is GTOPO30 with 30 arc seconds spacing. The digital elevation model was derived from several raster and vector sources of topographic information.

Please replace paragraph [023] with the following rewritten paragraph:

[023] The memory 212, 260 and 262 may be RAM, DRAM, SDRAM, EEPROM, a combination of RAM, DRAM, SDRAM, and EEPROM, or any other type of readwriteable memory. One skilled in the art will appreciate that all or part of systems and methods consistent with the present invention may be stored on or read from other machine-readable media, for

example, secondary storage devices such as hard disks, floppy disks, and CD-ROMs; a signal received from a network; or other forms of ROM or RAM either currently known or later developed. Further, although specific components of SATPS 100 are described, one skilled in the art will appreciate that a positioning system suitable for use with methods, systems, and articles of manufacture consistent with the present invention may contain additional or different components. For example, the navigation processor ~~process~~ 208 may be a microprocessor, microcontroller, application specific integrated circuit ("ASIC"), discrete or a combination of other types of circuits acting as a central processing unit.

Please replace paragraph [024] with the following rewritten paragraph:

[024] The digital terrain elevation data is processed along with the code phases to determine the location of the SATPS receiver 102. The navigation processor 208 forms four simultaneous equations with data retrieved from three SATPS spread spectrum signals and the digital terrain elevation data. The fourth equation derived from the digital terrain elevation data is a result of polynomial (in 2 variables of latitude φ and longitude λ) surface fit to the appropriate terrain. To select the appropriate terrain from the digital terrain elevation data in the digital terrain elevation data memory 262 located in server 250, the SATPS spread spectrum signals ~~signal~~ 116, 118 and 120 from the three satellites ~~satellite~~ 106, 108 and 110 are solved first for a fixed height "h". The fixed value of "h" may be initially assigned to the average value of "h" in the neighborhood of the base station (unlike known approaches of using the previous values of "h"). [[.]] Error in the fixed "h" is the absolute value of the difference between the average and the minimum or maximum value of "h". With this information, the three SATPS satellite position solution with fixed "h" comes with an estimated error ellipse.

Please replace paragraph [025] with the following rewritten paragraph:

[025] Grid points along the direction of the major and minor axes of the error ellipse are constructed by the navigation processor 208. The step sizes (along the directions of major and minor axes) are made proportional (1.5 times) to the magnitudes of the major and minor axes respectively. In other implementations, other step sizes may be employed along the major and minor axes. The center of the ellipse is the two-dimensional location determined from the three SATPS satellite signals 116, 118, 120 and the fixed "h". In other implementations, the step size may be different. In the current implementation, 25 points are chosen in the grid. In other implementations, different numbers ~~number~~ of points may be selected. Altitude values above the mean sea level at these points are obtained from the digital terrain elevation data (DTED) by indexing the four corner points in which the grid point resides and then using bilinear interpolation between the corner points. The obtained height values "H" are converted to World Geodetic Datum (WGS-84) "h" by adding the Geoid "N" separation derived from Earth Gravity Model (EGM-84) at the three SATPS satellite solution point determined from the three SATPS satellite signals 116, 118 and 120 and fixed "h". Earth Gravity Model EGM-96 or other types of earth gravity models may be employed for determining Geoid "N" separations.

Please replace paragraph [026] with the following rewritten paragraph:

[026] For the grid ~~gird~~ of 25 points of φ, λ and "h" a fourth order polynomial in φ and λ is found using the Least Square (LSQ) method, resulting in 15 coefficients needing to be determined. To handle ill conditioning the polynomial is found in new variables that represent a scaled deviation from the center point (the three SATPS satellite solution determined from the three SATPS satellite signals 116, 118 and 120 and fixed "h"). A numerical method of Q-R

decomposition is used, such as the modified Gram-Schmidt procedure, which makes Q only orthogonal rather than orthonormal (to avoid square root operations).

Please replace paragraph [030] with the following rewritten paragraph:

[030] In FIG. 3, a diagram of bilinear interpolation employed with digital terrain elevation data of FIG. 2 is shown. A table 300 of digital terrain elevation data of 1x1 degree increments is accessed from the South West Corner 302 (φ_r, λ_r) by row 304 and column 306. Given a latitude, φ_u and longitude, λ_u, the nearest South-West corner 302 of the table 300[[(]] (DTED data file) is found and used as a reference to find an index in table 300. This index is used to retrieve the H. In other implementations, a different position or corner of the available digital terrain elevation data and a data type other than DTED may be used with appropriate changes to the equations. The equations are:

Please replace paragraph [055] with the following rewritten paragraph:

[055] Where, l_i is the line of sight unit vector pointing from the receiver to SATPS satellite i and d is the down direction unit vector pointing along the downward normal to the WGS-84 ellipsoid, Δp_x, Δp_y and Δp_z are differential position coordinates, Δb is the differential pseudorange offset, $\Delta\rho_1$, $\Delta\rho_2$ and $\Delta\rho_3$ are differential pseudoranges, and Δh is the differential h. The line of sight unit vector is given by:

Please replace paragraph [072] with the following rewritten paragraph:

[072] The total number of coefficients, m, for degree, n are given by the recursive formula: m(n)=m(n-1)+(n+1) with m(0)=1. For degree, n=4, m=15. The coefficients, c_i, where i=l, . . . , m are obtained by solving the following linear equation using a least square method.

Please replace paragraph [082] with the following rewritten paragraph:

[082] The LSQ polynomial surface fit equation in the usual matrix notation is $A \bullet C=H$ and the objective in least squares solution is to minimize $(A \bullet C-H)^T \bullet W \bullet (A \bullet C-H)$, where W is a positive definite weighting matrix. The optimum solution is obtained by solving the set $A^T \bullet W \bullet A \bullet C=A^T \bullet W \bullet H$. This set can be written as $B^T \bullet B \bullet C=B^T \bullet \Gamma \bullet H$, by using the decomposition $W=\Gamma^T \bullet \Gamma$ and using $B=A \bullet \Gamma$. This new set can further be written as $R \bullet C=D^{-1} \bullet Q^T \bullet H$, where B is decomposed as $B=Q \bullet R$, with R unit upper triangular (diagonal elements of R are all ones and lower diagonals are all zeros) and such that $Q^T \bullet Q=D$, D being a diagonal matrix. The upper triangular set of equations can be solved using back-substitution method. In the above, two decompositions are used. The first is: $W= \Gamma^T \bullet \Gamma$. This can be done using Cholesky's method. Usually, W is diagonal and then so is Γ and it can be obtained simply by taking square roots of the diagonal elements of W. An even ~~Even~~ simpler case is when W=I, where I is an identity matrix and then Γ=I as well. This equal weighting is used in the solution. The second decomposition is $B=Q \bullet R$. This decomposition can be obtained by a modified Gram-Schmidt method that gives Q, R and D by avoiding square root operations since Q is only orthogonal (not orthonormal).

Please replace paragraph [083] with the following rewritten paragraph:

[083] The equations from the three pseudoranges and polynomial surface equation are solved by the LSQ solution method as described previously (using fixed "h") with two exceptions. The last (fourth) equation (fixed "h") is replaced by an altitude equation as a polynomial in φ and λ. With this change, it is convenient to consider the first three equations in the unknowns of φ, λ, and h, rather than in the ECEF frame. So, the equations are written as:

Please replace paragraph [089] with the following rewritten paragraph:

[089] A two-dimensional polynomial of degree 4 is fit in the variables of φ and λ with 15 coefficients to the 25 points previously obtained in step 510. The maximum residual error for the polynomial fit is determined and if the error exceeds a predetermined threshold in step 514, then an error message 516 is generated and processing is complete 518. Otherwise, if the predetermined threshold is not exceeded in step 514, then the SATPS pseudorange equations and the equation of the polynomial along with the maximum residual error of step 512 are solved to determine the position 520. In step 522, a check is made to determine if the φ and λ obtained in step 520 belong to the grid over which the surface-fit was done in step 512. If yes then the solution is accepted and processing is complete 518, otherwise the solution is rejected 524.

Please replace paragraph [090] with the following rewritten paragraph:

[090] The processing has been shown as being stopped 518 for illustrative purposes. In practice, processing may continue and start at step 502 again, enter an idle state until instructed to process new location information, or execute other plurality of machine-readable instructions that are stored in some type of memory. The steps previously described, may ~~my~~ occur with additional steps or with steps combined.